FORM PTO-1390 (REV. 9-2001)	U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY 'S DOCKET NUMBER 34420.00.0004
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U S. APPLICATION NO (If known see 37 CFR 1 5 **10/088069**

INTERNATIONAL APPLICATION NO. EP00/08805	INTERNATIONAL FILING DATE 8 SEPTEMBER 2000	PRIORITY DATE CLAIMED 09/09/1999

TITLE OF INVENTION
Hall Sensor Array for measuring a Magnetic Field with Offset Compensation

APPLICANT(S) FOR DO/EO/US
Hans-Peter Hohe et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.

4. ☑ The US has been elected by the expiration of 19 months from the priority date (Article 31).

5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
     a. ☐ is attached hereto (required only if not communicated by the International Bureau).
     b. ☑ has been communicated by the International Bureau.
     c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☑ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
     a. ☑ is attached hereto.
     b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).

7. ☐ Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
     a. ☐ are attached hereto (required only if not communicated by the International Bureau).
     b. ☐ have been communicated by the International Bureau.
     c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
     d. ☐ have not been made and will not be made.

8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).

9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. ☐ An English lanuage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. ☑ A FIRST preliminary amendment.

14. ☐ A SECOND or SUBSEQUENT preliminary amendment.

15. ☐ A substitute specification.

16. ☐ A change of power of attorney and/or address letter.

17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.

18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).

19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

20. ☑ Other items or information:

     Unsigned Declaration; Translation of Amendments under Art. 34 PCT
     attached to IPER; facsimile copy of International Application (in German)

U.S. APPLICATION NO (if known, See 37 CFR 1.5) 10/088069	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER

	CALCULATIONS PTO USE ONLY

21. ☐ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):

Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
and International Search Report not prepared by the EPO or JPO $1040.00

International preliminary examination fee (37 CFR 1.482) not paid to
USPTO but International Search Report prepared by the EPO or JPO $890.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO
but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $740.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO
but all claims did not satisfy provisions of PCT Article 33(1)-(4) $710.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO
and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	

Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	- 20 =	-0-	x $18.00	$	
Independent claims	- 3 =		x $84.00	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable) 5			+ $280.00	$	

TOTAL OF ABOVE CALCULATIONS =	$	

☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +	$	

SUBTOTAL =	$ 890.00	

Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	$	

TOTAL NATIONAL FEE =	$	

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +	$	

TOTAL FEES ENCLOSED =	$	

	Amount to be refunded:	$
	charged:	$ 890.00

a. ☐ A check in the amount of $ _____ to cover the above fees is enclosed.

b. ☑ Please charge my Deposit Account No. 22-0259 in the amount of $ 890.00 . to cover the above fees.
A duplicate copy of this sheet is enclosed.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
overpayment to Deposit Account No. 22-0259 . A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card
information should not be included on this form** Provide credit card information and authorization on PTO-2038.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR
1.137 (a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

Christopher J. Reckamp, Esq.
Vedder Price Kaufman & Kammholz
222 N. LaSalle Street, Suite 2600
Chicago, IL 60601-1104

March 8, 2002

_____
SIGNATURE

Christopher J. Reckamp
_____
NAME

34,414
_____
REGISTRATION NUMBER

☐ **RECEIVING OFFICE (RO/US)**

IN THE UNITED STATES ☒ **DESIGNATED OFFICE (DO/US)**

☐ **ELECTED OFFICE (EO/US)**

INTERNATIONAL APPLICATION NO	INTERNATIONAL FILING DATE	PRIORITY DATE ALLOWED
PCT EP00/08805	8 SEPTEMBER 2000	9 SEPTEMBER 1999

TITLE OF INVENTION   HALL SENSOR ARRAY FOR MEASURING A MAGNETIC FIELD WITH OFFSET COMPENSATION

APPLICANT(s)

HANS-PETER HOHE; NORBERT WEBER; JOSEF SAUERER

Box PCT
Commissioner of Patents and Trademarks

Washington DC 20231

PRELIMINARY AMENDMENT

Prior to examination, please amend the above-identified application as follows:

In the Specification:

On page 1, after the title, please replace the heading "Description" and substitute therefor the heading --Background of the Invention--.

On page 1, after the heading "Background of the Invention," before the first paragraph in the section, please add the heading –Field of the Invention—so that the paragraph reads as follows:

Field of the Invention

The present invention relates generally to Hall sensors and in particular to the arrangement and control of several Hall sensor elements in a Hall sensor array for magnetic field measurement with offset compensation.

On page 1, after the first paragraph under the "Field of the Invention" section, please insert the following heading: --Description of Prior Art--.

On page 1, at the second paragraph of the "Description of Related Art" section, please replace the current paragraph beginning at line 32, and substitute the following paragraph therefor so that the paragraph reads as follows:

A Hall sensor array in which two or four Hall sensor elements are used to compensate the disturbing effect of a particular crystal direction is known from the European patent specification EP-0548391 B1. The angular separation of the individual Hall sensor elements is fixed, lying between 0° and 180°. The angle is chosen according to the crystal direction of the semiconductor material which is used. According to EP-0548391 each Hall element is fed from a separate current source, so that a constant current is impressed on each element. The Hall voltages tapped off at the individual Hall elements in the Hall detector are connected in parallel in a switching stage. A common value is thus imposed on the Hall voltages of the individual elements, so that compensating currents may result.

On page 3, in the Summary of the Invention section, replace the first two paragraphs beginning at line 22 and substitute therefor the following paragraphs, so that the first two paragraphs read as follows:

It is the object of the present invention to provide an improved Hall sensor array which is also less complicated to manufacture.

This object is achieved by a Hall sensor array comprising:

a first and at least one additional pair of Hall sensor elements,

wherein each Hall sensor element has four terminals, of which two terminals act as power supply terminals for supplying an operating current and two terminals act as measurement terminals for measuring a Hall voltage,

wherein the Hall sensor elements are so arranged that the current directions of the operating current in the two Hall sensor elements of each pair are offset at an angle of approximately 90° to one another,

wherein the Hall sensor elements of the additional pair(s) are so arranged that their current directions of the operating current are offset at an angle of approximately 90°/n to the current directions of the operating current of the first pair of Hall sensor elements, n being the total number of Hal sensor element pairs, and

wherein respective first terminals of the measurement terminals of the Hall sensor elements and respective second terminals of the measurement terminals of the Hall sensor elements are connected together for measurement of the Hall voltage,

wherein the Hall sensor array also has switches and wherein the respective terminals of the Hall sensor elements are connected to the switches, so that the respective first and second supply terminals for supplying an operating current and the respective first and second measurement terminals for measuring a Hall voltage can be switched over from one measurement to a subsequent measurement in such a way that the current directions of the operating current in the Hall sensor elements and the Hall voltage tapping directions can be rotated through approximately 90° from one measurement to a subsequent measurement,

wherein the Hall sensor array also has a controller by means of which the switches are controllable in such a way that the Hall sensor array is operable in spinning current operation for generating a Hall signal and wherein the offset voltages of the Hall sensor elements approximately cancel one another out in a revolution so that the Hall signal contributions which actually depend on the magnetic field remain, and

wherein respective first supply terminals of each Hall sensor element are connected together and to a first terminal of a common voltage source and respective second supply terminals of each Hall sensor element are connected together and to the second terminal of the common voltage source so that the common voltage source supplies an operating current for the Hall sensor elements.

On page 5, please delete the paragraph beginning at line 17.

On page 6, at line 18, please substitute the below paragraph for the indicating pending paragraph, so that the paragraph reads as follows:

According to the present invention, the Hall sensor elements are operated in the so-called "spinning current" mode. In spinning current operation the measurement direction is rotated continuously in a cycle by e.g. 90° at a particular clock frequency, i.e. the operating current flows from one electrode to the facing contact electrode, the Hall voltage being tapped off at the transverse contact electrodes, whereupon the measurement direction is rotated through 90° at the next cycle, i.e. the next measurement phase. The Hall voltages measured in the individual measurement phases are evaluated by a suitable correctly signed

and weighted summation or subtraction. The offset still contained in the individual measurement phases can be reduced still further or the offset voltages during a revolution should roughly cancel one another out, so that the parts of the Hall signal which really depend on the magnetic field are retained.

In the Claims:

Please amend Claims 1-2 and 8-9 as follows and please delete, without prejudice, claims 3-7. In particular, please substitute the below claims for the indicated pending claims with the same number.

1.   (Once Amended) A Hall sensor array comprising:

a first and at least one additional pair of hall sensor elements,

wherein each hall sensor element has four terminals of which two act as power supply terminals for supplying an operating current and two terminals act as measurement terminals for measuring a Hall voltage,

wherein the Hall sensor elements are so arranged that the current directions of the operating current in the two Hall sensor elements of each pair are offset at an angle of approximately 90° to one another,

wherein the Hall sensor elements of the additional pair(s) are so arranged that their current directions of the operating current are offset at an angle of approximately 90°/n to the current directions of the operating current of the first pair of Hall sensor elements, n being the total number of Hall sensor element pairs, and

wherein respective first terminals of the measurement terminals of the Hall sensor elements and respective second terminals of the measurement terminals of the Hall sensor elements are connected together for measurement of the Hall voltage,

wherein the Hall sensor array also has switches and wherein the respective terminals of the Hall sensor elements are connected to the switches, so that the respective first and second supply terminals for supplying an operating current and the respective first and second measurement terminals for measuring a Hall voltage can be switched over from one measurement to a subsequent measurement in such a way that the current directions of the

operating current in the Hall sensor elements and the Hall voltage tapping directions can be rotated through approximately 90° from one measurement to a subsequent measurement,

wherein the Hall sensor array also has a controller by means of which the switches are controllable in such a way that the Hall sensor array is operable in spinning current operation for generating a Hall signal and wherein the offset voltages of the Hall sensor elements approximately cancel one another out in a revolution so that the Hall signal contributions which actually depend on the magnetic field remain, and

wherein first supply terminals of each Hall sensor element are connected together and to a first terminal of a common voltage source and respective second supply terminals of each Hall sensor element are connected together and to the second terminal of the common voltage source so that the common voltage source supplies an operating current for the Hall sensor elements.

2.   (Once Amended) Hall sensor array according to claim 1, wherein the first supply terminals are connected together electrically by being interwired, the second supply terminals are connected together electrically by being interwired, the first measurement terminals are connected together electrically by being interwired and the second measurement terminals are connected together electrically by being interwired.

8.   (Once Amended) Hall sensor array according to claim 1, wherein the Hall sensor elements of a pair are geometrically identical.

9.   (Once Amended) Hall sensor array according to claim 1, wherein the Hall sensor elements of different pairs are geometrically different.

In the Abstract:

Please delete the current paragraph in the Abstract section, and substitute therefor the below paragraph so that the Abstract to reads as follows:

ABSTRACT

A Hall sensor array for offset-compensated magnetic field measurement comprises a first and at least one additional pair of Hall sensor elements. Each Hall sensor element has four terminals, of which two act as power supply terminals for supplying an operating current and two act as measurement terminals for measuring a Hall voltage. Respective first supply

terminals of each Hall sensor element are connected together and to a first terminal of a common voltage source and respective second supply terminals of each hall sensor element are connected together and to a second terminal of the common voltage source so that the common voltage source supplies an operating current for the Hall sensor elements. The Hall sensor elements are operated in the spinning current mode so that the offset voltages of the Hall sensor elements approximately cancel one another out in a revolution so that the Hall signal contributions which actually depend on the magnetic field remain.

REMARKS

Applicants respectfully submit that the claims are in condition for allowance. The Examiner is invited to contact the below-listed attorney if the Examiner believes that a telephone conference will advance the prosecution of this application.

March 8, 2002

Respectfully submitted,

Christopher J. Reckamp
Reg. No. 34,414

Vedder, Price, Kaufman & Kammholz
222 N. LaSalle Street, Suite 2600
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In the Specification:

On page 1, after the title, please replace the heading "Description" and substitute therefor the heading --Background of the Invention--.

On page 1, after the heading "Background of the Invention," please add the heading – Field of the Invention—so that the paragraph reads as follows:

Field of the Invention.

The present invention relates generally to Hall sensors and in particular to the arrangement and control of several Hall sensor elements in a Hall sensor array for magnetic field measurement with offset compensation.

On page 1, after the first paragraph under the "Field of the Invention" section, please insert the following heading: --Description of Related Art--.

On page 1, at the second paragraph of the "Description of Related Art" section, please replace the current paragraph and substitute the following paragraph therefor, so that the paragraph reads as follows:

A Hall sensor array in which two or four Hall sensor elements are used to compensate the disturbing effect of a particular crystal direction is known from the European patent specification EP-0548391 B1. The angular separation of the individual Hall sensor elements is fixed, lying between 0° and 180°. The angle is chosen according to the crystal direction of the semiconductor material which is used. According to EP-0548391 each Hall element is fed from a separate current source, so that a constant current is impressed on each element. The Hall voltages tapped off at the individual Hall elements in the Hall detector are connected in parallel in a switching stage. A common value is thus imposed on the Hall voltages of the individual elements, so that compensating currents may result.

On page 3, in the Summary of the Invention section, replace the first two paragraphs beginning at line 22 and substitute therefor the following paragraphs, so that the first two paragraphs read as follows:

[Starting from this prior art it]It is the object of the present invention to provide an improved Hall sensor array which is also less complicated to manufacture.

This object is achieved by a Hall sensor array comprising:

a first and at least one additional pair of Hall sensor elements,

wherein each Hall sensor element has four terminals, of which two terminals act as power supply terminals for supplying an operating current and two terminals act as measurement terminals for measuring a Hall voltage,

wherein the Hall sensor elements are so arranged that the current directions of the operating current in the two Hall sensor elements of each pair are offset at an angle of approximately 90° to one another,

wherein the Hall sensor elements of the additional pair(s) are so arranged that their current directions of the operating current are offset at an angle of approximately 90°/n to the current directions of the operating current of the first pair of Hall sensor elements, n being the total number of Hal sensor element pairs, and

wherein respective first terminals of the measurement terminals of the Hall sensor elements and respective second terminals of the measurement terminals of the Hall sensor elements are connected together for measurement of the Hall voltage,

wherein the Hall sensor array also has switches and wherein the respective terminals of the Hall sensor elements are connected to the switches, so that the respective first and second supply terminals for supplying an operating current and the respective first and second measurement terminals for measuring a Hall voltage can be switched over from one measurement to a subsequent measurement in such a way that the current directions of the operating current in the Hall sensor elements and the Hall voltage tapping directions can be rotated through approximately 90° from one measurement to a subsequent measurement,

wherein the Hall sensor array also has a controller by means of which the switches are controllable in such a way that the Hall sensor array is operable in spinning current operation for generating a Hall signal and wherein the offset voltages of the Hall sensor elements approximately cancel one another out in a revolution so that the Hall signal contributions which actually depend on the magnetic field remain, and

wherein respective first supply terminals of each Hall sensor element are connected together and to a first terminal of a common voltage source and respective second supply terminals of each Hall sensor element are connected together and to the second terminal of the common voltage source so that the common voltage source supplies an operating current for the Hall sensor elements[according to claim 1].

On page 5, please delete the paragraph beginning at line 17.

[The present invention provides a Hall sensor array for offset compensated magnetic field measurement which comprises a first and at least one additional pair of Hall sensor elements. Each Hall sensor element has four terminals, of which a first and a third terminal act as power supply terminals for supplying an operating current and a second and a fourth terminal set as measurement terminals for measuring a hall voltage. The Hall sensor elements are so arranged that the current directions of the operating current in the two Hall sensor elements of each pair are offset at an angle of approximately 90° to one another. The Hall sensor elements of the additional pair(s) are so arranged that their operating current directions are offset at an angle of approximately 90°/n to the operating current directions of the first pair of Hall sensor elements, n being the total number of Hall sensor element pairs and $n \geq 2$. The first terminals, the third terminals, the second terminals and the fourth terminals of the Hall sensor elements are respectively connected to each other electrically. The operating current can thus be supplied over the first and third terminals of all the Hall sensor elements and the Hall voltage can be measured over the second and fourth terminals of all the Hall sensor elements.]

On page 6, at line 18, please substitute the below paragraph for the indicating pending paragraph, so that the paragraph reads as follows:

According to the present invention, [The geometric arrangement and interwiring of] the Hall sensor elements are operated in [according to the present invention is particularly important for] the so-called "spinning current" mode[operation]. In spinning current operation the measurement direction is rotated continuously in a cycle by e.g. 90° at a particular clock frequency, i.e. the operating current flows from one electrode to the facing contact electrode, the Hall voltage being tapped off at the transverse contact electrodes, whereupon the measurement direction is rotated through 90° at the next cycle, i.e. the next measurement phase. The Hall voltages measured in the individual measurement phases are

evaluated by a suitable correctly signed and weighted summation or subtraction. The offset still contained in the individual measurement phases can be reduced still further or the offset voltages during a revolution should roughly cancel one another out, so that the parts of the Hall signal which really depend on the magnetic field are retained.

In the Claims

Please amend Claims 1-2 and 8-9 as follows. In particular, please substitute the below claims for the indicated pending claims with the same number.

1.   (Once Amended) A Hall sensor array comprising:

a first [(1A, 1B)]and at least one additional pair[2A, 2B,; 2A, 2B, 3A, 3B)] of Hall sensor elements,

wherein each hall sensor element[(1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B)] has four terminals[(K1, K2, K3, K4)], of which two [a first and a third] [terminal]terminals [(K1, K2)] act as power supply terminals for supplying an operating current[($I_{operation}$)] and two [a second and a fourth terminal]terminals act as measurement terminals for measuring a Hall voltage[(U_{Hall})],

wherein the Hall sensor elements [(1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B)]are so arranged that the current directions of the operating current [($I_{operation}$)]in the two Hall sensor elements of each pair are offset at an angle of approximately 90° to one another,

wherein the Hall sensor elements[(2A, 2B; 2A, 2B, 3A, 3B;)] of the additional pair(s) are so arranged that their [operating]current directions of the operating current are offset at an angle of approximately 90°/n to the current directions of the operating current [directions]of the first pair [(1A, 1B)]of Hall sensor elements, n being the total number of Hall sensor element pairs[and n ≥ 2], and

wherein respective[the] first terminals of the measurement terminals[terminal (K1), the third terminals (K3), the second terminals (K2) and the fourth terminals (K4)] of the Hall sensor elements [(1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B) are respectively]and respective second terminals of the measurement terminals of the Hall sensor elements are connected together for measurement of the Hall voltage,

wherein the Hall sensor array also has switches and wherein the respective terminals of the Hall sensor elements are connected to the switches, so that the respective first and second supply terminals for supplying an operating current and the respective first and second measurement terminals for measuring a Hall voltage can be switched over from one measurement to a subsequent measurement in such a way that the current directions of the operating current in the Hall sensor elements and the Hall voltage tapping directions can be rotated through approximately 90° from one measurement to a subsequent measurement, [each other electrically, thus permitting the operating element ($I_{operation}$) to be supplied over the electrically interlinked first and third terminals (K1, K3) of all the Hall sensor elements and the Hall voltage (U_{Hall}) to be measured over the electrically interlinked second and fourth terminals (K2, K4) of all the Hall sensor elements (1A, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B)]

wherein the Hall sensor array also has a controller by means of which the switches are controllable in such a way that the Hall sensor array is operable in spinning current operation for generating a Hall signal and wherein the offset voltages of the Hall sensor elements approximately cancel one another out in a revolution so that the Hall signal contributions which actually depend on the magnetic field remain, and

wherein first supply terminals of each Hall sensor element are connected together and to a first terminal of a common voltage source and respective second supply terminals of each Hall sensor element are connected together and to the second terminal of the common voltage source so that the common voltage source supplies an operating current for the Hall sensor elements.

2.   (Once Amended) Hall sensor array according to claim 1, wherein the first supply terminals [(K1] are connected together electrically by being interwired, [the third terminals (K3),]the second supply terminals[(K2]are connected together electrically by being interwired, [and the fourth]the first measurement terminals [(K4) of the Hall sensor elements (1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B)] are [respectively] connected together electrically by being interwired and the second measurement terminals are connected together electrically by being interwired.

[3. Hall sensor array according to claim 1 or 2, wherein the Hall sensor elements of the first and the second pair respectively are arranged next to each other.]

[4.   Hall sensor array according to claim 1 or 2, wherein the Hall sensor elements of the first and the second pair are arranged along a diagonal.]

[5.   Hall sensor array according to one of the claims 1 to 4, wherein the Hall sensor elements of the first and the second pair are arranged close to one another relative to the dimensions of the Hall sensor elements.]

[6.   Hall sensor array according to one of the claims 1 to 5, which also includes switches (S1, S2, S3, S4) and where the terminals (K1, K2, K3, K4) of the Hall sensor elements (1A, 1B, 2A, 2B) are connected to the switches (S1, S2, S3, S4), so that the power supply terminals for supplying an operating current ($I_{operation}$) and the measurement terminals for measuring a Hall voltage (U_{Hall}) can be switched through 90° from one measurement to the next.

[7.   Hall sensor array according to one of the claims 1 to 6, which also includes a control unit by means of which the switches (S1, S2, S3, S4) are controllable in such a way that the Hall sensor array is operable in spinning current operation.]

8.   Hall sensor array according to [one of the]claim[s] 1 [to 7], wherein the Hall sensor elements of a pair are geometrically identical.

9.   Hall sensor array according to [one of the] claim[s] 1 [to 8], wherein the Hall sensor elements of different pairs are geometrically different.

In the Abstract:

Please delete the current paragraph in the Abstract section, and substitute therefor the below paragraph so that the Abstract to reads as follows:

[Hall Sensor Array for Measuring a Magnetic Field with Offset Compensation]

ABSTRACT

A Hall sensor array for offset-compensated magnetic field measurement comprises a first [(1A, 1B)] and at least one additional pair[(2A, 2B, 2A, 2B, 3A, 3B)] of Hall sensor elements. Each Hall sensor element [(1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B)] has four terminals [(K1, K2, K3, K4)], of which two [a first and a third terminal (K1, K3)] act as power supply terminals for supplying an operating current [($I_{operation}$)]and two [a second and

a fourth terminal (K2, K4)]act as measurement terminals for measuring a Hall voltage[(U_{Hall})]. Respective first supply terminals of each Hall sensor element are connected together and to a first terminal of a common voltage source and respective second supply terminals of each Hall sensor element are connected together and to a second terminal of the common voltage source so that the common voltage source supplies an operating current for the Hall sensor elements. The Hall sensor elements [(1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B)] are operated in the spinning current mode so that the offset voltages of the Hall sensor elements approximately cancel one another out in a revolution so that the Hall signal contributions which actually depend on the magnetic field remain[so arranged that the current directions of the operating current ($I_{operation}$) in the two Hall sensor elements of each pair are offset at an angle of approximately 90° to one another. The Hall sensor elements (2A, 2B; 2A, 2B, 3A, 3B) of the additional pair(s) are so arranged that their operating current directions are offset at an angle of approximately 90°/n to the operating current directions of the first pair (1A, 1B) of Hall sensor elements, n being the total number of Hall sensor element pairs and n ≥ 2. The first terminals (K1), the third terminals (K3), the second terminals (K2) and the fourth terminals (K4) of the Hall sensor elements (1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B) are respectively connected to each other electrically. The operating current ($I_{operation}$) can thus be supplied over the first and third terminals (K1, K3) of all the Hall sensor elements and the Hall voltage (U_{Hall}) can be measured over the second and fourth terminals (K2, K4) of all the Hall sensor elements (1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B)].

Hall Sensor Array for Measuring a Magnetic Field
with Offset Compensation

5   Description

The present invention relates generally to Hall sensors and
in particular to the arrangement and control of several Hall
sensor elements in a Hall sensor array for magnetic field
10   measurement with offset compensation.

An individual Hall sensor element generally consists of an n-
doped active semiconductor region on a p-doped semiconductor
substrate. The n-doped active region is normally connected to
15   an external control logic via four contact electrodes or con-
tact terminals which are arranged diagonally opposite one an-
other in the active region. The four contact electrodes of
the Hall sensor element subdivide into two facing control
current contact electrodes, which serve to generate a current
20   flow through the active region, and two facing voltage tap-
ping contact electrodes, which serve to tap a Hall voltage,
which arises when a magnetic field is applied at right angles
to the current flow in the active region, to act as a sensor
signal.
25
A Hall sensor array in which two or four Hall sensor elements
are used to compensate the disturbing effect of a particular
crystal direction is known from the European patent specifi-
cation EP-0548391 B1. The angular separation of the individ-
30   ual Hall sensor elements is fixed, lying between $0°$ and $180°$.
The angle is chosen according to the crystal direction of the
semiconductor material which is used.

As is known, inhomogeneities or faults in the semiconductor material of the active region often arise in the manufacturing processes of semiconductor structures due to the nature of production. Even with very refined manufacturing methods,

5 these inhomogeneities cannot be avoided completely. These inhomogeneities are often the cause of an offset of the sensor signal. This means that a sensor signal is detected at the contact electrodes at which the Hall voltage is tapped off even when no magnetic field is being applied to the active

10 region. This disturbing sensor signal is termed the offset of the useful sensor signal or simply the offset signal. Owing to the strong dependence of the offset signal on the inhomogeneities, traditional Hall sensor elements are subject to considerable scatter from one element to another. In addition

15 there is a marked adverse effect on the sensitivity and measurement accuracy of the Hall sensors. For this reason, offset compensation and the correct evaluation of the sensor signals generally entail a costly circuit investment.

20 So-called piezo effects, which are strongly dependent on the crystal direction of the semiconductor material used, constitute another problem area in Hall sensor arrays. These piezo effects can produce a considerable offset signal through mechanical stresses caused by external forces (e.g. due to the

25 housing) or through mechanical stresses in the crystal lattice of the semiconductor material. Attempts have been made to overcome these problems, either by matching the Hall sensor array to the crystal direction of the semiconductor material or by compensating the piezo effects through a suitable

30 choice of the current directions in the semiconductor material depending on the crystal direction. However, these measures involve very complicated manufacturing processes for the Hall sensor arrays since it is necessary to take into account

Translation of PCT Application

both the crystal orientation of the semiconductor surface and also the orientation of the Hall sensor elements to one another and in relation to the crystal orientation.

5   Starting from this prior art it is the object of the present invention to provide an improved Hall sensor array which is also less complicated to manufacture.

This object is achieved by a Hall sensor array according to
10   claim 1.

The present invention provides a Hall sensor array for offset-compensated magnetic field measurement which comprises a first and at least one additional pair of Hall sensor ele-
15   ments. Each Hall sensor element has four terminals, of which a first and a third terminal act as power supply terminals for supplying an operating current and a second and a fourth terminal act as measurement terminals for measuring a Hall voltage. The Hall sensor elements are so arranged that the
20   current directions of the operating current in the two Hall sensor elements of each pair are offset at an angle of approximately 90° to one another. The Hall sensor elements of the additional pair(s) are so arranged that their operating current directions are offset at an angle of approximately
25   90°/n to the operating current directions of the first pair of Hall sensor elements, n being the total number of Hall sensor element pairs and n ≥ 2. The first terminals, the third terminals, the second terminals and the fourth terminals of the Hall sensor elements are respectively connected
30   to each other electrically. The operating current can thus be supplied over the first and third terminals of all the Hall sensor elements and the Hall voltage can be measured over the second and fourth terminals of all the Hall sensor elements.

Translation of PCT Application

The present invention is based on the finding that the sensor
signal offset contribution in a Hall sensor array can be
greatly reduced through the above geometrical arrangement of
5   the individual Hall sensor elements of the pairs and the in-
terwiring of the terminals, making it possible to supply an
offset signal which is already precompensated. With the ar-
rangement and interwiring of the Hall sensor elements accord-
ing to the present invention it is possible to make the meas-
10 ured Hall voltage independent of the crystal direction of the
semiconductor material.

The geometric arrangement and interwiring of the Hall sensor
elements according to the present invention is particularly
15 important for the so-called "spinning current" operation. In
spinning current operation the measurement direction is ro-
tated continuously in a cycle by e.g. 90° at a particular
clock frequency, i.e. the operating current flows from one
electrode to the facing contact electrode, the Hall voltage
20 being tapped off at the transverse contact electrodes, where-
upon the measurement direction is rotated through 90° at the
next cycle, i.e. the next measurement phase. The Hall volt-
ages measured in the individual measurement phases are evalu-
ated by a suitable correctly signed and weighted summation or
25 subtraction. The offset still contained in the individual
measurement phases can be reduced still further or the offset
voltages during a revolution should roughly cancel one an-
other out, so that the parts of the Hall signal which really
depend on the magnetic field are retained.
30
Because of the orientation and interwiring of the Hall sensor
elements according to the present invention it is no longer
necessary to take the crystal direction of the semiconductor

material into account, whereby the influence on the measured
Hall voltage of the piezo effects dependent on the crystal
direction of the semiconductor material can effectively be
eliminated completely.

5

Since the strong dependence of the offset signal both on the
crystal direction of the semiconductor material and on the
inhomogeneities and irregularities in the semiconductor mate-
rial is effectively eliminated by the Hall sensor array ac-
10   cording to the present invention, a considerable increase in
the sensitivity and measurement accuracy is achieved by means
of this Hall sensor array. This permits the complexity of the
circuitry needed for correct evaluation and further process-
ing of the sensor signals to be reduced in the Hall sensor
15   array according to the present invention.

The improved sensitivity and measurement accuracy resulting
from the lower offset contribution of the sensor signal of
the Hall sensor array also results in an increase in the ex-
20   ploitable resolution of the measured Hall voltage.

A further advantage of the present invention is that the cir-
cuit complexity of the Hall sensor array can be reduced fur-
ther since the fixed interwiring of the Hall sensor elements
25   makes it possible to apply a common operating current to all
the Hall sensor elements and to have a common tap-off for all
the Hall signals of the Hall sensor elements. This avoids the
need to supply a separate operating current to each sensor
element individually and to measure separately the Hall volt-
30   age of each sensor element. This avoids the need for addi-
tional circuit components, e.g. additional switches, current
sources, feed lines, etc. Furthermore, the complexity of the
evaluation circuit can be simplified.

Translation of PCT Application

Preferred embodiments of the present invention are discussed in more detail below making reference to the enclosed drawings, in which

5

Fig. 1   shows a schematic representation of a Hall sensor array with four Hall sensor elements according to the present invention;

10   Fig. 2a-c   show schematic representations of further alternative geometrical embodiments and arrangements of the Hall sensor elements according to the present invention; and

15   Fig. 3a-b: show schematic representations of further alternative geometrical arrangements of the Hall sensor elements according to the present invention.

The general structure of a Hall sensor array with two pairs
20   of Hall sensor elements will now be described making reference to Fig. 1.

On a semiconductor substrate, which is preferably p-doped, four rectangular active semiconductor regions are introduced,
25   these usually being n-doped. Contact electrodes K1, K2, K3, K4, which are generally obtained by n^+-doping, are preferably arranged in the corners of the n-doped active region. The contact electrodes K1, K2, K3, K4 in the n-doped active region are arranged diagonally opposite each other in pairs,
30   two contact electrodes K1, K3 serving to feed in the operating current and the other two contact electrodes K2, K4 to tap off the Hall voltage. The active regions constitute the individual Hall sensor elements 1A, 2A, 1B, 2B. In the Hall

sensor array with four Hall sensor elements shown in Fig. 1 the Hall sensor elements 1A, 1B and the Hall sensor elements 2A, 2B respectively constitute a Hall sensor element pair.

5   Fig. 1 shows an embodiment in which the two Hall sensor element pairs are positioned in a square, the individual pairs of Hall sensor elements being arranged diagonally. However, the two Hall sensor elements of a pair in the Hall sensor array can also be positioned one below the other or next to
10   each other.

In a preferred embodiment of the Hall sensor array according to the present invention the contact electrodes K1, the contact electrodes K2, the contact electrodes K3 and the contact
15   electrodes K4 of the individual Hall sensor elements 1A, 2A, 1B, 2B are respectively connected in parallel and are wired together without intermediate switches. In the representation shown the contact electrodes K1 and the contact electrodes K3 of the Hall sensor elements 1A, 2A, 1B, 2B constitute the
20   current feed contacts while the contact electrodes K2 and the contact electrodes K4 of the Hall sensor elements 1A, 2A, 1B, 2B provide the measurement terminals for measuring a Hall voltage. The contact electrodes for feeding in an operating current and the contact electrodes for measuring a Hall volt-
25   age are so arranged in the individual Hall sensor elements that the current direction of the impressed operating current is in each case perpendicular to the direction of the tapped Hall voltage.

30   In preferred embodiments of the present invention the operating current directions in the two Hall sensor elements of each pair are oriented at 90° to each other. The current directions of the second Hall sensor element pair are offset at

an angle of 45° to the current directions of the first Hall sensor element pair.

In the practical implementation of the Hall sensor array according to the present invention the angle at which the operating current directions in the two Hall sensor elements of each pair are oriented to one another can deviate from the ideal value of 90° and lie in a range of e.g. 80° to 100°, angles in this range being regarded as angles of essentially 90° in the sense of the present invention. This applies also to the angle by which the current directions of the second Hall sensor element pair are offset relative to the current directions of the first Hall sensor element pair, which can be chosen to be e.g. in the range 40° to 50° and thus effectively equal to 45°. It should be noted, however, that the offset compensation of the Hall sensor array which is achieved may decrease with increasing deviation from the ideal angles considered as optimal, namely 90° and 45°.

The rigidly interwired contact electrodes K1, K2, K3, K4 of the Hall sensor elements 1A, 2A, 1B, 2B are connected to switches S1, S2, S3, S4, each of which can be switched between four positions, i.e. between the contact electrodes K1, K2, K3, K4. With the switches S1, S2, S3, S4 the contact electrodes K1, K2, K3, K4 can respectively be switched over together to act as power supply terminals for supplying an operating current $I_{operation}$, or as measurement terminals for measuring a Hall voltage U_{Hall}.

A further embodiment of the Hall sensor array according to the present invention (not shown explicitly) can provide more than two pairs of Hall sensor elements. In this case, too, the operating current directions in the two Hall sensor ele-

ments of each pair are oriented substantially at 90° to each other. Here, too, the two Hall sensor elements of each pair must be geometrically the same and be close to one another relative to the dimensions of the Hall sensor elements and they can be arranged one under the other, next to each other or along a diagonal in the complete sensor array. The current directions of the two or more Hall sensor element pairs are respectively oriented at an angle of essentially 90°/n to one another, n being the total number of Hall sensor element pairs which are used and n ≥ 2. For example, if three Hall sensor element pairs are used, the current directions of the individual Hall sensor element pairs are offset at an angle of approximately 30° to each other. The element pairs of the sensor array are arranged either next to each other or along the diagonal, the pairs of Hall sensor elements being as close to one another as possible.

In this arrangement, too, the contact electrodes for supplying an operating current $I_{operation}$ (or a supply voltage) and also the contact electrodes for tapping the Hall voltage U_{Hall} are connected in parallel and rigidly wired together without intervening switches.

Through the Hall sensor array with two pairs of Hall sensor elements, see Fig. 1, or with several pairs of Hall sensor elements according to the present invention the geometric placing of the Hall sensor elements already results in a pre-compensated offset signal in each measurement phase. This means e.g. that a subsequent amplifier can be operated with higher amplification since it cannot so easily become saturated. Through the cyclic changeover (e.g. spinning current operation) of the operating current directions and a suitable correctly signed and weighted summation or subtraction of the

signals of the individual measurement phases, the precompensated sensor signal offset contribution which still remains in the individual measurement phases during spinning current operation is reduced further since the sensor signal offset
5 contributions due to inhomogeneities and stresses in the semiconductor material are substantially eliminated.

The specified geometric arrangement of the sensors is advantageous here since the offset contribution of a single Hall
10 sensor element with only four terminals is smaller than that of a Hall sensor element with a different geometry, e.g. with eight contact electrodes. The resulting offset contribution which remains after cyclic changeover and weighting is therefore also smaller. With its geometric arrangement for the
15 Hall sensor array and employing the spinning current method the arrangement according to the present invention provides a Hall voltage with an extremely small offset contribution. This Hall voltage is also independent of the crystal direction used in the Hall sensor array manufacturing process and
20 of the orientation of the Hall sensor elements to this crystal direction.

The Hall sensor array is usually implemented as a monolithic integrated component, which can also accommodate not only the
25 Hall sensor array but also a current supply for the Hall sensor elements as well as an electronic evaluation circuit for the Hall voltage. Traditional silicon semiconductor technology employing known bipolar or MOS manufacturing processes generally provides the basis for manufacturing this circuit
30 arrangement. With the arrangement according to the present invention the known disadvantages of silicon as a Hall sensor element material, i.e. a low Hall sensitivity and the big influence of the piezo effect, which leads to the sensor signal

offset contribution, and also the influence of inhomogenei-
ties in the semiconductor material, can substantially be
overcome.

5   With the parallel connection of the respective contact elec-
trodes K1, K2, K3, K4 of the individual Hall sensor elements,
which has been described above, only four output terminals
are provided in the Hall sensor array treated here. With
relatively simple circuitry it is possible to switch between
10 these from one measurement phase to the next and to connect
them to the evaluation electronics. With this fixed wiring it
is possible not only to achieve the advantages as regards
offset compensation described above but also to keep the cir-
cuitry simple, thus making possible a simpler and therefore
15 cheaper fabrication of these Hall sensor arrays compared with
traditional Hall sensors.

To clarify the concept according to the present invention
some examples of other alternative arrangements of the Hall
20 sensor elements according to the present invention are de-
scribed below. It should be noted that the Hall sensor ele-
ments of a pair must be geometrically identical to each
other, whereas, on the other hand, the Hall sensor elements
of different pairs may have different geometries. Thus addi-
25 tional optimization can be achieved for individual applica-
tions or areas of application of the Hall sensor array.

In Fig. 2a the Hall sensor element pairs 1A, 1B and 2A, 2B
are respectively arranged next to one another and the Hall
30 sensor elements of both pairs have the same geometric form.

Translation of PCT Application

In Fig. 2b the Hall sensor element pairs 1A, 1B and 2A, 2B are respectively arranged next to one another and the Hall sensor elements of both pairs have different geometric forms.

5   In Fig. 2c the Hall sensor element pairs 1A, 1B and 2A, 2B are respectively arranged diagonally and the Hall sensor elements of both pairs have different geometric forms.

A further advantageous possibility for the geometric arrangement of the individual Hall sensor element pairs is to place
10 the Hall sensor elements so that the midpoints of the individual Hall sensor elements lie on a circle.

An example of the geometric arrangement for two pairs of Hall sensor elements 1A, 1B and 2A, 2B is shown in Fig. 3a. Con-
15 necting lines L1, L2 represent the imaginary connection between the geometric midpoints of the two Hall sensor elements of a pair. The connecting lines L1, L2 of the two pairs of Hall sensor elements 1A, 1B and 2A, 2B intersect at a point
20 M, which represents the geometric midpoint of the whole Hall sensor array. In this geometric arrangement the midpoints of the individual Hall sensor elements 1A, 1B and 2A, 2B lie symmetrically on an imaginary circle U with midpoint M.

25 Fig. 3b shows an example of a geometric arrangement for three pairs of Hall sensor elements. Connecting lines L1, L2, L3 represent the imaginary connection between the geometric midpoints of the two Hall sensor elements of a pair. The connecting lines L1, L2, L3 of the three pairs of Hall sensor
30 elements 1A, 1B, 2A, 2B, 3A, 3B intersect at a point M, which represents the geometric midpoint of the whole Hall sensor array. In this geometric arrangement the midpoints of the in-

dividual Hall sensor elements 1A, 1B, 2A, 2B, 3A, 3B lie symmetrically on an imaginary circle U with midpoint M.

All the Hall sensor arrays described above provide the advantages as regards simplified circuitry demands and improved offset properties described herein.

Claims

1.   Hall sensor array comprising:

5   a first (1A, 1B) and at least one additional pair (2A,
        2B; 2A, 2B, 3A, 3B) of Hall sensor elements,

        wherein each Hall sensor element (1A, 1B, 2A, 2B; 1A,
        1B, 2A, 2B, 3A, 3B) has four terminals (K1, K2, K3, K4),
10   of which a first and a third terminal (K1, K3) act as
        power supply terminals for supplying an operating cur-
        rent ($I_{operation}$) and a second and a fourth terminal (K2,
        K4) act as measurement terminals for measuring a Hall
        voltage (U_{Hall}),
15

        wherein the Hall sensor elements (1A, 1B, 2A, 2B; 1A,
        1B, 2A, 2B, 3A, 3B) are so arranged that the current di-
        rections of the operating current ($I_{operation}$) in the two
        Hall sensor elements of each pair are offset at an angle
20   of approximately 90° to one another,

        wherein the Hall sensor elements (2A, 2B; 2A, 2B, 3A,
        3B) of the additional pair(s) are so arranged that their
        operating current directions are offset at an angle of
25   approximately 90°/n to the operating current directions
        of the first pair (1A, 1B) of Hall sensor elements, n
        being the total number of Hall sensor element pairs and
        n ≥ 2, and

30   wherein the first terminals (K1), the third terminals
        (K3), the second terminals (K2) and the fourth terminals
        (K4) of the Hall sensor elements (1A, 1B, 2A, 2B; 1A,
        1B, 2A, 2B, 3A, 3B) are respectively connected to each

other electrically, thus permitting the operating current ($I_{operation}$) to be supplied over the electrically interlinked first and third terminals (K1, K3) of all the Hall sensor elements and the Hall voltage (U_{Hall}) to be measured over the electrically interlinked second and fourth terminals (K2, K4) of all the Hall sensor elements (1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B).

2. Hall sensor array according to claim 1, wherein the first terminals (K1), the third terminals (K3), the second terminals (K2) and the fourth terminals (K4) of the Hall sensor elements (1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B) are respectively connected together electrically by being interwired.

3. Hall sensor array according to claim 1 or 2, wherein the Hall sensor elements of the first and the second pair respectively are arranged next to each other.

4. Hall sensor array according to claim 1 or 2, wherein the Hall sensor elements of the first and the second pair are arranged along a diagonal.

5. Hall sensor array according to one of the claims 1 to 4, wherein the Hall sensor elements of the first and the second pair are arranged close to one another relative to the dimensions of the Hall sensor elements.

6. Hall sensor array according to one of the claims 1 to 5, which also includes switches (S1, S2, S3, S4) and wherein the terminals (K1, K2, K3, K4) of the Hall sensor elements (1A, 1B, 2A, 2B) are connected to the switches (S1, S2, S3, S4), so that the power supply ter-

minals for supplying an operating current ($I_{operation}$) and the measurement terminals for measuring a Hall voltage (U_{Hall}) can be switched through 90° from one measurement to the next.

5

7. Hall sensor array according to one of the claims 1 to 6, which also includes a control unit by means of which the switches (S1, S2, S3, S4) are controllable in such a way that the Hall sensor array is operable in spinning cur-
10 rent operation.

8. Hall sensor array according to one of the claims 1 to 7, wherein the Hall sensor elements of a pair are geometrically identical.

15

9. Hall sensor array according to one of the claims 1 to 8, wherein the Hall sensor elements of different pairs are geometrically different.

Translation of PCT Application

Hall Sensor Array for Measuring a Magnetic Field with Offset Compensation

Abstract

A Hall sensor array for offset-compensated magnetic field measurement comprises a first (1A, 1B) and at least one additional pair (2A, 2B; 2A, 2B, 3A, 3B) of Hall sensor elements. Each Hall sensor element (1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B) has four terminals (K1, K2, K3, K4), of which a first and a third terminal (K1, K3) act as power supply terminals for supplying an operating current ($I_{operation}$) and a second and a fourth terminal (K2, K4) act as measurement terminals for measuring a Hall voltage (U_{Hall}). The Hall sensor elements (1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B) are so arranged that the current directions of the operating current ($I_{operation}$) in the two Hall sensor elements of each pair are offset at an angle of approximately 90° to one another. The Hall sensor elements (2A, 2B; 2A, 2B, 3A, 3B) of the additional pair(s) are so arranged that their operating current directions are offset at an angle of approximately 90°/n to the operating current directions of the first pair (1A, 1B) of Hall sensor elements, n being the total number of Hall sensor element pairs and n ≥ 2. The first terminals (K1), the third terminals (K3), the second terminals (K2) and the fourth terminals (K4) of the Hall sensor elements (1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B) are respectively connected to each other electrically. The operating current ($I_{operation}$) can thus be supplied over the first and third terminals (K1, K3) of all the Hall sensor elements and the Hall voltage (U_{Hall}) can be measured over the second and fourth terminals (K2, K4) of all the Hall sensor elements (1A, 1B, 2A, 2B; 1A, 1B, 2A, 2B, 3A, 3B).
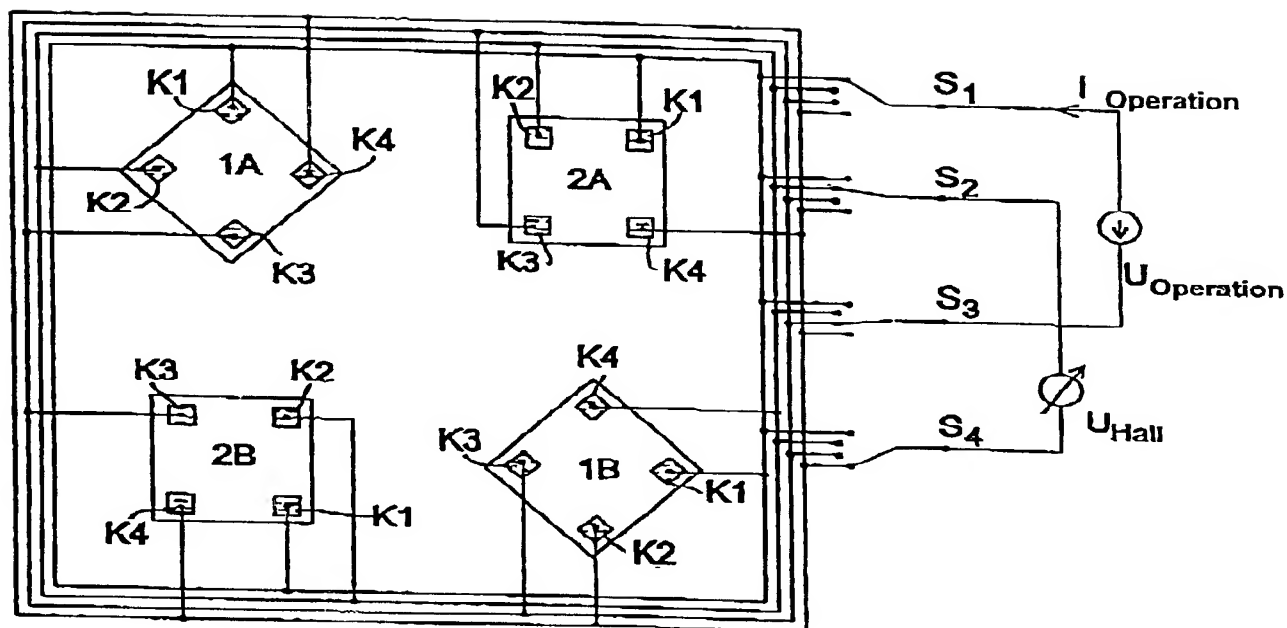
Fig. 1

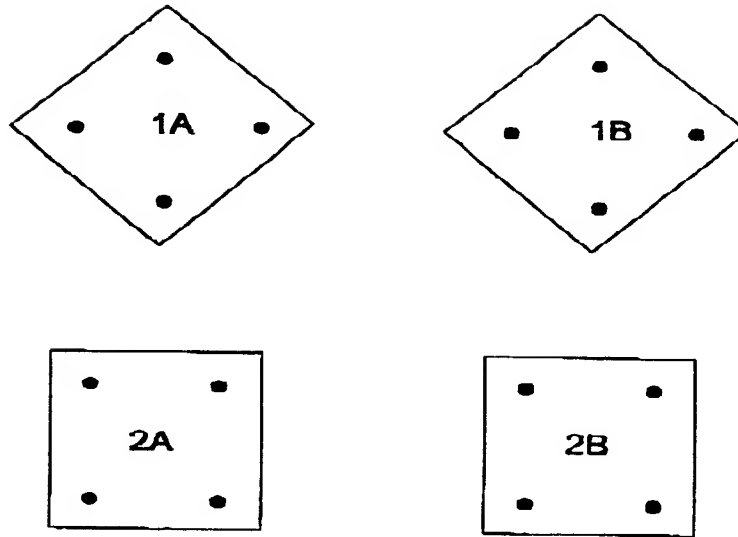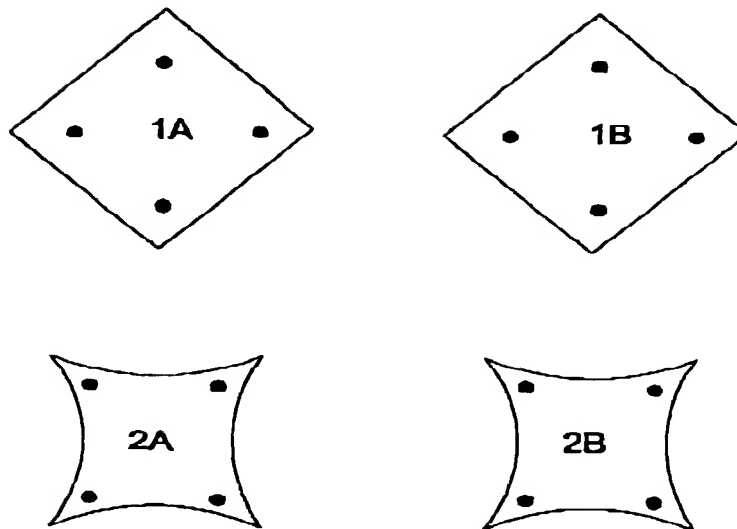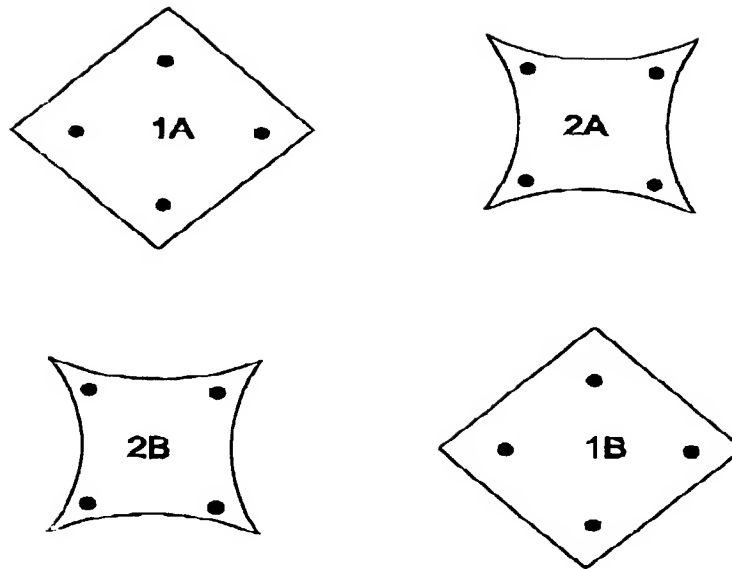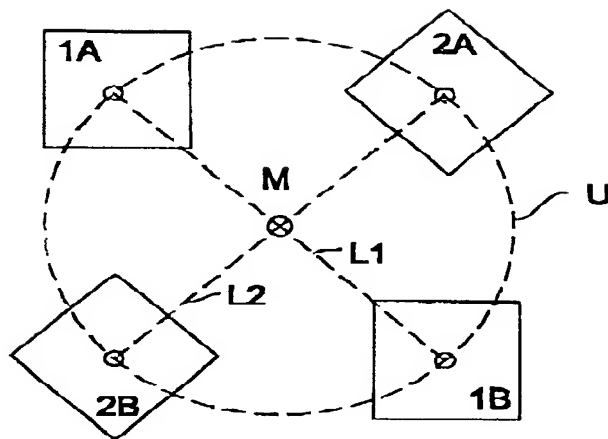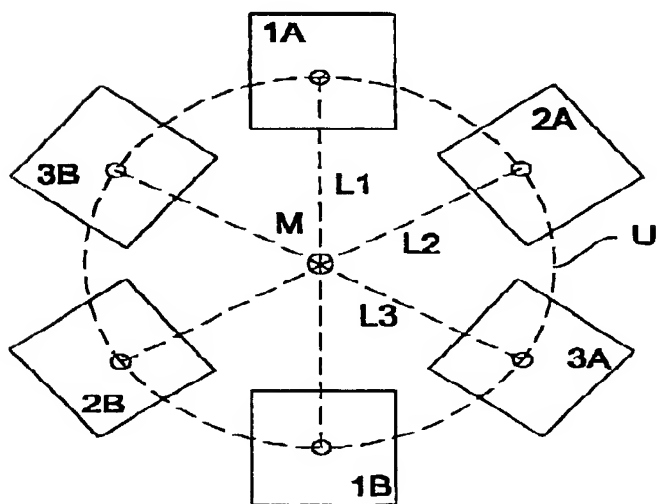Fig. 2a

Fig. 2b

Fig. 2c

Fig. 3a

Fig. 3b

DECLARATION
FOR UTILITY OR DESIGN
PATENT APPLICATION
(37 CFR 1.63)
☐ Declaration Submitted with Initial Filing, OR
☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)) required)

Attorney Docket Number 33420.00.0004_____
First Named Inventor: Hans-Peter Hohe et al._____
COMPLETE IF KNOWN
Application Number: *10/088,069*
Filing Date: March 8, 2002_____
Group Art Unit: _____
Examiner Name: _____

As a below named inventor, I hereby declare that:
My residence, post office address, and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: HALL SENSOR ARRAY FOR MEASURING A MAGNETIC FIELD WITH OFFSET COMPENSATION

the specification of which:
☐ is attached hereto.
☒ was filed on September 8, 2000 as PCT International Application Number PCT EP 00/08805 and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.
I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Copy Attached? YES NO	
19943128.0	Germany	09/09/1999	☐	☐	☒
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Data (MM/DD/YYYY)

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under 35 U S C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U S C 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transaction all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Name of Additional Joint Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])		Family Name or Surname		
Inventor's Signature		Date		
Residence	City:	State	Country:	Citizenship
Post Office Address				
City:	State:		ZIP:	Country:

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

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